JC13 Rec'd PCT/PTO 04 APR 2002

FORM PTO-1390 (REV 5-93) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
420/50943

U S APPLICATION NO (if known, see 37 CFR 1.5)
10/089735 Not Yet Assigned

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/03478	**2 October 2000**	**5 October 1999**

TITLE OF INVENTION
SOUND PRESSURE LEVEL CALIBRATOR

APPLICANT(S) FOR DO/EO/US
Guenther MUELLER and Josef STEIGENBERGER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1.	X	This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.		
2.		This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371		
3.		This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay Examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).		
4.	X	A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.		
5.	X	A copy of the International Application as filed (35 U.S.C. 371(c)(2)).		
		a.		is transmitted herewith (required only if not transmitted by the International Bureau).
		b.	X	has been transmitted by the International Bureau
		c.		is not required, as the application was filed in the United States Receiving Office (RO/US)
6.	X	A translation of the International Application into English (35 U.S.C. 371(c)(2)).		
7.		Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))		
		a.		are transmitted herewith (required only if not transmitted by the International Bureau).
		b.		have been transmitted by the International Bureau.
		c.		have not been made; however, the time limit for making such amendments has NOT expired.
		d.		have not been made and will not be made.
8.		A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).		
9.	X	An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) WITH APPLICATION DATA SHEET		
10.	X	A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).		

Item 11. to 16. below concern other document(s) or information included:

11.	X	An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12.	X	An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13.	X	A FIRST preliminary amendment.
		A SECOND or SUBSEQUENT preliminary amendment.
14.	X	A substitute specification and marked-up copy thereof.
15.		A change of power of attorney and/or address letter.
16.	X	Other items or information:

a. PCT/IPEA/416 Preliminary Examination Report with 1 amended sheet
b. PCT/IB/308
c. International Search Report

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U.S. APPLICATION NO (if known, see 37 CFR 1.5	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER	
Not Yet Assigned 10/089735	PCT/DE00/03478	420/50943	
17. [X] The following fees are submitted:		CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO	$ 890.00	$ 890.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482)	$ 690.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)	$ 740.00		
Neither international preliminary examination fee (37 CFR 1.482) nor International search fee (37CFR 1.445(a)(2) paid to USPTO	$ 1000.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)	$ 100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	5 - 20 =	0	X $18.00	$	
Independent Claims	2 - 3 =	0	X $84.00	$	
Multiple dependent claims(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS=				$ 890.00	
Applicant claims Small Entity Status (See 37 CFR §1.27) [ ] yes [ ] no. Reduction by 1/2 for filing by small entity, if applicable.				$	
SUBTOTAL =				$890.00	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28,3.31). $40.00 per property +				$ 40.00	
TOTAL FEE ENCLOSED =				$ 930.00	
				Amount to be: refunded	$
				Charged	$

a. [X] Two checks in the amount of $ 890.00 for the filing fee and $40.00 for the assignment recording fee are enclosed

b. [ ] Please charge my Deposit Account No. ______ in the amount of $______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any overpayment to Deposit Account No. 05-1323 . A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:	
Crowell & Moring, LLP	SIGNATURE
P.O. Box 14300	[signature]
Washington, D.C. 20044-4300	NAME: Vincent J. Sunderdick
Tel. No. (202) 624-2500	
Fax No. (202) 628-8844	REGISTRATION NUMBER: 29,004
	DATE : April 4, 2002

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APPLICATION DATA SHEET

INVENTOR INFORMATION

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Citizenship Country::	Federal Republic of Germany	

CORRESPONDENCE INFORMATION

Correspondence customer number:: 23911

APPLICATION INFORMATION

Title line one::	Sound Pressure Level Calibrator
Total drawing sheets::	1
Formal drawings?::	Yes
Application type::	Utility
Docket Number::	420/50943

REPRESENTATIVE INFORMATION

Representative customer number::	23911

CONTINUITY INFORMATION

This application is a::	**371** of
Application one::	PCT/DE00/03478
Filing date::	2 October 2000
Patent number::	

PRIOR FOREIGN APPLICATIONS

Foreign application one::	DE 199 47 6837
Filing date::	October 5, 1999
Country::	Germany
Priority claimed::	Yes

10/089735
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Attorney Docket: 420/50943
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	GUNTHER MULLER ET AL.		
Serial No.:	Not Yet Assigned	Group Art Unit:	Unknown
Filed:	Concurrently Herewith	Examiner:	Unknown
Title:	ACOUSTIC PRESSURE CALIBRATOR		

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following amendments to the claims and abstract prior to the examination of the application.

IN THE CLAIMS:

Please amend claims 1, 2 and 3 as follows:

(A copy of the marked-up version of amended claims 1, 2 and 3 are attached to this Preliminary Amendment).

1. (Amended) A sound pressure level calibrator for calibrating a sound pressure level sensor, comprising;

a pistonphone for producing a sound pressure;

and a high-pressure adapter, which is connected to an output of the pistonphone, wherein

the high-pressure adapter includes a $\lambda/4$ resonator to amplify the produced sound pressure and an expanded adapter opening with a sealing ring for a soundproof connection to a said sound pressure level sensor to be calibrated.

Amended Claim 1

1. Sound pressure level calibrator for calibrating a sound pressure level sensor, comprising a pistonphone (1) for producing a sound pressure and a high-pressure adapter (2), which is connected to an output of the pistonphone (1),
characterized in that
the high-pressure adapter (2) is embodied as a $\lambda/4$ resonator to amplify the produced sound pressure and has an expanded adapter opening (7) with a sealing ring (8) for a soundproof connection to a sound pressure level sensor that is to be calibrated.

2. (Amended) The sound pressure level calibrator as claimed in Claim 1, wherein the resonator is a tube of a length (L) with a constant diameter (d).

3. (Amended) The sound pressure level calibrator as claimed in claim 1, wherein the high pressure adapter, further includes an integral mechanical compensation link in order to improve the soundproof connection of the high pressure adapter to the sound pressure level sensor.

Please add the following new claims:

4. (New) A method for calibrator a sound pressure level sensor comprising the steps of:

providing a piston phone for producing a sound pressure;

amplifying the produced sound pressure by means of a high-pressure adapter which includes a $\lambda/4$ resonator, and an expanded adapter opening with a sealing ring in order to provide soundproof connection to said sound pressure level sensor to be calibrated.

5. (New) The method according to claim 4 further comprising the step of forming a mechanical compensation link integral with the high pressure adapter in order to improve the soundproof connection of the high pressure adapter to the sound pressure level sensor.

IN THE ABSTRACT:

Please substitute the new Abstract of the Disclosure submitted herewith on a separate page for the original Abstract presently in the application.

REMARKS

Entry of the amendments to the claims and abstract before examination of the application is respectfully requested. These claims are fully supported by the specification.

If there are any questions regarding this Preliminary Amendment or this application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

It is respectfully requested that, if necessary to effect a timely response, this paper be considered as a Petition for an Extension of Time sufficient to effect a timely response and shortages in other fees, be charged, or any overpayment in fees be credited, to the Account of Evenson, McKeown, Edwards & Lenahan, P.L.L.C., Deposit Account No. 05-1323 (Docket #420/50943).

Respectfully submitted,

April 4, 2002

Vincent J. Sunderdick
Registration No. 29,004

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

1. [Sound] A sound pressure level calibrator for calibrating a sound pressure level sensor, comprising:

a pistonphone [(1)] for producing a sound pressure;

and a high-pressure adapter [(2)], which is connected to an output of the pistonphone [(1)], wherein the [characterized in that]

the high-pressure adapter [(2) [is embodied as] includes a $\lambda/4$ resonator to amplify the produced sound pressure and [has] an expanded adapter opening [(7)] with a sealing ring [(8)] for a soundproof connection to a said sound pressure level sensor [that is] to be calibrated.

2. [Sound] The sound pressure level calibrator as claimed in Claim 1, [characterized in that] wherein the resonator [(6) is embodied as] is a tube of a length (L) with a constant diameter (d).

3. [Sound] The sound pressure level calibrator as claimed in claim 1, wherein [one of claims 1 or 2, characterized in that, to improve the soundproof connection of] the high pressure adapter [(2) to the sound pressure level sensor a], further includes an integral mechanical compensation link [(9) is integrated in the high pressure adapter (2) and a sealing ring is inserted into the adapter opening (7)] in order to improve the soundproof connection of the high pressure adapter to the sound pressure level sensor.

ABSTRACT OF THE DISCLOSURE

A sound pressure level calibrator, which is suitable for sound pressures to be measured in excess of 124 dB and which can be adapted to the installed sound pressure level sensor. This object is attained by a sound pressure level calibrator comprising a pistonphone and a high-pressure adapter connected to the output of the pistonphone. The high-pressure adapter acts as a resonator. With an expanded adapter opening the high-pressure adapter is connected in soundproof manner with the sound pressure level sensor, which is inserted into a structure . The invention can be used for a sound pressure level calibrator to calibrate a sound pressure level sensor, which is integrated into a structure.

SOUND PRESSURE LEVEL CALIBRATOR

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This application claims the priority of German Application DE 199 47 6837, filed October 5, 1999, and PCT/DE00/03478, filed October 2, 2000, the disclosure of which is expressly incorporated by reference herein.

[0002] The invention relates to a sound pressure level calibrator. The calibration of sound pressure level sensors is generally carried out with commercially available sound pressure level calibrators that can produce a maximum sound pressure of 94 dB or 124 dB. To measure sound pressure levels, calibration must be conducted with levels that are nearly as high as the levels to be measured in order to achieve the required measuring accuracy and to be able to check the required dynamics of the recording device of the measuring chain, e.g., a tape recorder, for optimum level control of the recording device. The sound pressure level of commercially available sound pressure level calibrators, which is limited in height, cannot always meet these requirements.

[0003] Furthermore, the sound pressure level calibrators of the prior art require the removal for calibration of the sound pressure level sensor from its supporting structure to adapt it to the commercially available sound pressure level calibrators. In prolonged measuring tests with frequent calibration processes, this required removal is very time-consuming and labor intensive. The frequent installation and removal also involves the risk that the sensitive sound pressure level sensor may be damaged.

[0004] The object of the invention is to provide a sound pressure level calibrator that is suitable for sound levels to be measured in excess of 124 dB and that can be adapted to the installed sound pressure level sensor.

[0005] The solution according to the invention is based on a high-pressure adapter on a commercially available pistonphone, which advantageously acoustically amplifies the sound pressure emitted by the pistonphone to values > 150 dB and permits the in situ calibration of the sound pressure level sensor.

[0006] This makes it possible to conduct calibration in situ immediately prior to the start of the measuring process on the entire measuring chain and to take measurements with relatively high accuracy even if the sound pressure levels are high. In addition, the adapter advantageously permits the calibration of different sound pressure level sensors through adaptation modules.

[0007] Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] With reference to the drawing, an exemplary embodiment of the invention will now be described in greater detail. The figure is a schematic sketch of the sound pressure level calibrator according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] The sound pressure level calibrator depicted in the figure comprises a pistonphone 1, a high-pressure adapter 2 connected to the output of the pistonphone, and a sound pressure level sensor 3.

[0010] The pistonphone 2 has a piston 4 for producing sound pressure and an adjustable pistonphone volume 5. The high-pressure adapter 2 comprises a λ/4 resonator 6 with an expanded adapter opening 7 for a soundproof connection of the high-pressure adapter to the sound pressure level sensor 3 by means of a sealing ring 8. A mechanical compensation link 9 is integrated into the high-pressure adapter 2. In contrast to a rigid design of the high-pressure adapter 2, this compensation link simplifies the soundproof connection between the high-pressure adapter 2 and the sound pressure level sensor 3 if the components are not completely aligned. The sound pressure level sensor 3 remains in its structure 10 during calibration. For static pressure, the pistonphone volume 5 is ventilated via a resistance bore. The λ/4 resonator 6 is embodied as a tube with a constant diameter.

[0011] In pistonphone 1, the adjustable pistonphone volume 5 is sinusoidally compressed with frequency f by piston 4, and the λ/4 resonator tube is excited by the dynamic pressure fluctuations produced thereby. The high-pressure adapter 2 embodied as a λ/4 resonator amplifies the sound pressure produced in the pistonphone volume and, via its adapter opening 7, applies this amplified sound pressure to the sound pressure level sensor 3.

[0012] The adjustable pistonphone volume 5 and the length of the λ/4 resonator 6 can be tuned to one another by mechanical means such that the acoustic coupling effect and thus the amplification of the λ/4 resonator 6 is established at a maximum. The executed fine-tuning can be locked by mechanical means. The constructional means for executing tuning and locking are accessible to the person skilled in the art without requiring an inventive step and their embodiment is therefore not further described here.

[0013] The physical relationships (G1) to (G4) listed below may be used as an approximate basis for the design of the sound pressure level calibrator.

$$p_l = \frac{\chi \cdot p_o \cdot s \cdot l}{2V}$$

p_l dynamic pressure in the pistonphone volume

χ kappa air

p_o static air pressure in the environment

s piston area

l piston amplitude (tip to tip)

V pistonphone volume

$$P1 = \frac{p_l \cdot 2 \cdot \pi \cdot f_a \cdot \rho \cdot L_e}{4(1 + 0.4\frac{L}{2R})\sqrt{\rho \cdot \pi \cdot \nu \cdot f_a}}$$

P1 dynamic pressure on the sensor-side output of the λ/4 resonator

p_l dynamic pressure in the pistonphone volume

f_A excitation frequency on the piston

ρ density of the air

L length of the resonator tube

L_e effective length of the λ/4 resonator (approximately 0.58 L)

R radius of the λ/4 resonator

ν dynamic viscosity of the air

$$P2 = P1\,\frac{d^2}{D^2}$$

P2 dynamic pressure at the membrane of the sound pressure level sensor

P1 dynamic pressure on the sensor-side output of the λ/4 resonator

d diameter of the $\lambda/4$ resonator

D diameter of the adapter opening

For a selected excitation frequency of $f_A = 314$ Hz, the above equations G1 to G3 can be used to estimate the sound pressure level P2 at the membrane of the sound pressure level sensor at : 152.8 dB re. 2E-5 Pa. The actual tube length, due to the additional spring effect of the pistonphone volume, which occurs parallel to the spring effect of the $\lambda/4$ resonator, must be designed greater than the tube length L theoretically resulting from the excitation frequency f_A, so that resonance occurs between the excitation frequency f_A and the vibration system. The actual tube length L for the $\lambda/4$ resonator results from the selected frequency f of the vibration system and the adaptation of the spring constant k2.

$$f = \frac{1}{2\pi}\sqrt{\frac{k1+k2}{M}}$$

f frequency of the vibration system at resonance

k1 spring constant of the pistonphone volume

k2 spring constant of the $\lambda/4$ resonator

M vibrating mass of the $\lambda/4$ resonator

[0014] The control measurement of a sound pressure level calibrator designed in accordance with equations G1 to G4 for the selected excitation frequency $F_A = 314$ Hz resulted in a sound pressure level of 151.3 dB. This measured value is lower than the value of 152.8 dB resulting from equations G1 to G4, which is attributable to boundary and friction influences. However, the equations G1 to G4 reflect well the obtainable order of magnitude for the sound pressure level at the sound pressure level calibrator according to the invention.

[0015] The reproducibility of the sound pressure level calibrator according to the invention by means of a measurement series extending over 24 days results in a deviation from the mean value of the measured sound pressure level of approximately +/– 0.3 dB. These deviations are partly attributable to air pressure and temperature changes, which were not corrected when the measurement series was recorded.

[0016] The above measurement results for level amplification and reproducibility are determined with piezo transducers. If sound pressure level sensors with softer measurement membranes are calibrated, the achievable level amplifications will be somewhat lower.

[0017] The sound pressure level calibrator <u>is</u> adjusted in the laboratory by means of a calibrated measuring chain, which corresponds to the sound pressure level sensor to be calibrated and has comparable installation conditions.

10/089735
Attorney Docket No. 420/50943
Marked-up Substitute Specification
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Sound Pressure Level Calibrator

BACKGROUND AND SUMMARY OF THE INVENTION

This application claims the priority of German application DE 199 47 6837, filed October 5, 1999, and PCT/DE00/03478, filed October 2, 2000, the disclosure of which is expressly incorporated by reference herein.

The invention relates to a sound pressure level calibrator [in accordance with the preamble of Claim 1]. The calibration of sound pressure level sensors is generally carried out with commercially available sound pressure level calibrators that can produce a maximum sound pressure of 94 dB or 124 dB. To measure sound pressure levels, calibration must be conducted with levels that are nearly as high as the levels to be measured in order to achieve the required measuring accuracy and to be able to check the required dynamics of the recording device of the measuring chain, e.g., a tape recorder, for optimum level control of the recording device. The sound pressure level of commercially available sound pressure level calibrators, which is limited in height, cannot always meet these requirements.

Furthermore, the sound pressure level calibrators of the prior art require the removal for calibration of the sound pressure level sensor from its supporting structure to adapt it to the commercially available sound pressure level calibrators. In prolonged measuring tests with frequent calibration processes, this required removal is very time-consuming and labor intensive. The frequent installation and removal also involves the risk that the sensitive sound pressure level sensor may be damaged.

The object of the invention is to provide a sound pressure level calibrator that is suitable for sound levels to be measured in excess of 124 dB and that can be adapted to the installed sound pressure level sensor.

[This object is attained by the invention by the features of Claim 1. Further embodiments of the invention are set forth in the dependent claims.]

The solution according to the invention is based on a high-pressure adapter on a commercially available pistonphone, which advantageously acoustically amplifies the sound pressure emitted by the pistonphone to values > 150 dB and permits the in situ calibration of the sound pressure level sensor.

This makes it possible to conduct calibration in situ immediately prior to the start of the measuring process on the entire measuring chain and to take measurements with relatively high accuracy even if the sound pressure levels are high. In addition, the adapter advantageously permits the calibration of different sound pressure level sensors through adaptation modules.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the drawing, an exemplary embodiment of the invention will now be described in greater detail. The figure is a schematic sketch of the sound pressure level calibrator according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The sound pressure level calibrator depicted in the figure comprises a pistonphone 1, a high-pressure adapter 2 connected to the output of the pistonphone, and a sound pressure level sensor 3.

The pistonphone 2 has a piston 4 for producing sound pressure and an adjustable pistonphone volume 5. The high-pressure adapter 2 comprises a $\lambda/4$ resonator 6 with an expanded adapter opening 7 for a soundproof connection of the high-pressure adapter to the sound pressure level sensor 3 by means of a sealing ring 8. A mechanical compensation link 9 is integrated into the high-pressure adapter 2. In contrast to a rigid design of the high-pressure adapter 2, this compensation link simplifies the soundproof connection between the high-pressure adapter 2 and the sound pressure level sensor 3 if the components are not completely aligned. The sound pressure level sensor 3 remains in its structure 10 during calibration. For static pressure, the pistonphone volume 5 is ventilated via a resistance bore. The $\lambda/4$ resonator 6 is embodied as a tube with a constant diameter.

In pistonphone 1, the adjustable pistonphone volume 5 is sinusoidally compressed with frequency f by piston 4, and the $\lambda/4$ resonator tube is excited by the dynamic pressure fluctuations produced thereby. The high-pressure adapter 2 embodied as a $\lambda/4$ resonator amplifies the sound pressure produced in the pistonphone volume and, via its adapter opening 7, applies this amplified sound pressure to the sound pressure level sensor 3.

The adjustable pistonphone volume 5 and the length of the $\lambda/4$ resonator 6 can be tuned to one another by mechanical means such that the acoustic coupling effect and thus the amplification of the $\lambda/4$ resonator 6 is established at a maximum. The

executed fine-tuning can be locked by mechanical means. The constructional means for executing tuning and locking are accessible to the person skilled in the art without requiring an inventive step and their embodiment is therefore not further described here.

The physical relationships (G1) to (G4) listed below may be used as an approximate basis for the design of the sound pressure level calibrator.

$$p_l = \frac{\chi \cdot p_o \cdot s \cdot l}{2V}$$

p_l	dynamic pressure in the pistonphone volume
χ	kappa air
p_o	static air pressure in the environment
s	piston area
l	piston amplitude (tip to tip)
V	pistonphone volume

$$P1 = \frac{p_l \cdot 2 \cdot \pi \cdot f_a \cdot \rho \cdot L_e}{4(1 + 0.4\frac{L}{2R})\sqrt{\rho \cdot \pi \cdot v \cdot f_a}}$$

P1	dynamic pressure on the sensor-side output of the λ/4 resonator
p_l	dynamic pressure in the pistonphone volume
f_A	excitation frequency on the piston
ρ	density of the air
L	length of the resonator tube
L_e	effective length of the λ/4 resonator (approximately 0.58 L)
R	radius of the λ/4 resonator
v	dynamic viscosity of the air

$$P2 = P1 \frac{d^2}{D^2}$$

P2 dynamic pressure at the membrane of the sound pressure level sensor

P1 dynamic pressure on the sensor-side output of the λ/4 resonator

d diameter of the λ/4 resonator

D diameter of the adapter opening

For a selected excitation frequency of $f_A = 314$ Hz, the above equations G1 to G3 can be used to estimate the sound pressure level P2 at the membrane of the sound pressure level sensor at : 152.8 dB re. 2E-5 Pa. The actual tube length, due to the additional spring effect of the pistonphone volume, which occurs parallel to the spring effect of the λ/4 resonator, must be designed greater than the tube length L theoretically resulting from the excitation frequency f_A, so that resonance occurs between the excitation frequency f_A and the vibration system. The actual tube length L for the λ/4 resonator results from the selected frequency f of the vibration system and the adaptation of the spring constant k2.

$$f = \frac{1}{2\pi}\sqrt{\frac{k1+k2}{M}}$$

f frequency of the vibration system at resonance

k1 spring constant of the pistonphone volume

k2 spring constant of the λ/4 resonator

M vibrating mass of the λ/4 resonator

The control measurement of a sound pressure level calibrator designed in accordance with equations G1 to G4 for the selected excitation frequency $F_A = 314$ Hz resulted in a sound pressure level of 151.3 dB. This measured value is lower than

the value of 152.8 dB resulting from equations G1 to G4, which is attributable to boundary and friction influences. However, the equations G1 to G4 reflect well the obtainable order of magnitude for the sound pressure level at the sound pressure level calibrator according to the invention.

The reproducibility of the sound pressure level calibrator according to the invention by means of a measurement series extending over 24 days results in a deviation from the mean value of the measured sound pressure level of approximately +/– 0.3 dB. These deviations are partly attributable to air pressure and temperature changes, which were not corrected when the measurement series was recorded.

The above measurement results for level amplification and reproducibility are determined with piezo transducers. If sound pressure level sensors with softer measurement membranes are calibrated, the achievable level amplifications will be somewhat lower.

The sound pressure level calibrator [should be] is adjusted in the laboratory by means of a calibrated measuring chain, which corresponds to the sound pressure level sensor to be calibrated and has comparable installation conditions.

1/prts

Sound Pressure Level Calibrator

The invention relates to a sound pressure level calibrator in accordance with the preamble of Claim 1.

The calibration of sound pressure level sensors is generally carried out with commercially available sound pressure level calibrators that can produce a maximum sound pressure of 94 dB or 124 dB. To measure sound pressure levels, calibration must be conducted with levels that are nearly as high as the levels to be measured in order to achieve the required measuring accuracy and to be able to check the required dynamics of the recording device of the measuring chain, e.g., a tape recorder, for optimum level control of the recording device. The sound pressure level of commercially available sound pressure level calibrators, which is limited in height, cannot always meet these requirements.

Furthermore, the sound pressure level calibrators of the prior art require the removal for calibration of the sound pressure level sensor from its supporting structure to adapt it to the commercially available sound pressure level calibrators. In prolonged measuring tests with frequent calibration processes, this required removal is very time-consuming and labor intensive. The frequent installation and removal also involves the risk that the sensitive sound pressure level sensor may be damaged.

The object of the invention is to provide a sound pressure level calibrator that is suitable for sound levels to be measured in excess of 124 dB and that can be adapted to the installed sound pressure level sensor.

This object is attained by the invention by the features of Claim 1. Further embodiments of the invention are set forth in the dependent claims.

The solution according to the invention is based on a high-pressure adapter on a commercially available pistonphone, which advantageously acoustically amplifies the

sound pressure emitted by the pistonphone to values > 150 dB and permits the in situ calibration of the sound pressure level sensor.

This makes it possible to conduct calibration in situ immediately prior to the start of the measuring process on the entire measuring chain and to take measurements with relatively high accuracy even if the sound pressure levels are high. In addition, the adapter advantageously permits the calibration of different sound pressure level sensors through adaptation modules.

With reference to the drawing, an exemplary embodiment of the invention will now be described in greater detail. The figure is a schematic sketch of the sound pressure level calibrator according to the invention.

The sound pressure level calibrator depicted in the figure comprises a pistonphone 1, a high-pressure adapter 2 connected to the output of the pistonphone, and a sound pressure level sensor 3.

The pistonphone 2 has a piston 4 for producing sound pressure and an adjustable pistonphone volume 5. The high-pressure adapter 2 comprises a $\lambda/4$ resonator 6 with an expanded adapter opening 7 for a soundproof connection of the high-pressure adapter to the sound pressure level sensor 3 by means of a sealing ring 8. A mechanical compensation link 9 is integrated into the high-pressure adapter 2. In contrast to a rigid design of the high-pressure adapter 2, this compensation link simplifies the soundproof connection between the high-pressure adapter 2 and the sound pressure level sensor 3 if the components are not completely aligned. The sound pressure level sensor 3 remains in its structure 10 during calibration. For static pressure, the pistonphone volume 5 is ventilated via a resistance bore. The $\lambda/4$ resonator 6 is embodied as a tube with a constant diameter.

In pistonphone 1, the adjustable pistonphone volume 5 is sinusoidally compressed with frequency f by piston 4, and the $\lambda/4$ resonator tube is excited by the dynamic pressure fluctuations produced thereby. The high-pressure adapter 2 embodied as a

$\lambda/4$ resonator amplifies the sound pressure produced in the pistonphone volume and via its adapter opening 7 applies this amplified sound pressure to the sound pressure level sensor 3.

The adjustable pistonphone volume 5 and the length of the $\lambda/4$ resonator 6 can be tuned to one another by mechanical means such that the acoustic coupling effect and thus the amplification of the $\lambda/4$ resonator 6 is established at a maximum. The executed fine-tuning can be locked by mechanical means. The constructional means for executing tuning and locking are accessible to the person skilled in the art without requiring an inventive step and their embodiment is therefore not further described here.

The physical relationships (G1) to (G4) listed below may be used as an approximate basis for the design of the sound pressure level calibrator.

[see source for equation] (G1)

p_1	dynamic pressure in the pistonphone volume
χ	kappa air
p_o	static air pressure in the environment
s	piston area
l	piston amplitude (tip to tip)
V	pistonphone volume

[see source for equation] (G2)

P1	dynamic pressure on the sensor-side output of the $\lambda/4$ resonator
p_1	dynamic pressure in the pistonphone volume
f_A	excitation frequency on the piston
ρ	density of the air

L length of the resonator tube

L_e effective length of the λ/4 resonator (approximately 0.58 L)

R radius of the λ/4 resonator

ν dynamic viscosity of the air

[see source for equation] (G3)

P2 dynamic pressure at the membrane of the sound pressure level sensor

P1 dynamic pressure on the sensor-side output of the λ/4 resonator

d diameter of the λ/4 resonator

D diameter of the adapter opening

For a selected excitation frequency of f_A = 314 Hz, the above equations G1 to G3 can be used to estimate the sound pressure level P2 at the membrane of the sound pressure level sensor at : 152.8 dB re. 2E-5 Pa. The actual tube length, due to the additional spring effect of the pistonphone volume, which occurs parallel to the spring effect of the λ/4 resonator, must be designed greater than the tube length L theoretically resulting from the excitation frequency f_A, so that resonance occurs between the excitation frequency f_A and the vibration system. The actual tube length L for the λ/4 resonator results from the selected frequency f of the vibration system and the adaptation of the spring constant k2.

[see source for equation] (G4)

f	frequency of the vibration system at resonance
k1	spring constant of the pistonphone volume
k2	spring constant of the $\lambda/4$ resonator
M	vibrating mass of the $\lambda/4$ resonator

The control measurement of a sound pressure level calibrator designed in accordance with equations G1 to G4 for the selected excitation frequency $F_A = 314$ Hz resulted in a sound pressure level of 151.3 dB. This measured value is lower than the value of 152.8 dB resulting from equations G1 to G4, which is attributable to boundary and friction influences. However, the equations G1 to G4 reflect well the obtainable order of magnitude for the sound pressure level at the sound pressure level calibrator according to the invention.

The reproducibility of the sound pressure level calibrator according to the invention by means of a measurement series extending over 24 days results in a deviation from the mean value of the measured sound pressure level of approximately +/– 0.3 dB. These deviations are partly attributable to air pressure and temperature changes, which were not corrected when the measurement series was recorded.

The above measurement results for level amplification and reproducibility are determined with piezo transducers. If sound pressure level sensors with softer measurement membranes are calibrated, the achievable level amplifications will be somewhat lower.

The sound pressure level calibrator should be adjusted in the laboratory by means of a calibrated measuring chain, which corresponds to the sound pressure level sensor to be calibrated and has comparable installation conditions.

Claims

1. Sound pressure level calibrator for calibrating a sound pressure level sensor, comprising a pistonphone (1) for producing a sound pressure and a high-pressure adapter (2), which is connected to an output of the pistonphone (1) and acts as a resonator (6),
characterized in that
the high-pressure adapter (2) has an expanded adapter opening (7) for a soundproof connection to a sound pressure level sensor that is to be calibrated and that is integrated into a structure (10).

2. Sound pressure level calibrator as claimed in Claim 1, characterized in that the resonator (6) is embodied as a tube of a length (L) with a constant diameter (d).

3. Sound pressure level calibrator as claimed in one of claims 1 or 2, characterized in that, to improve the soundproof connection of the high pressure adapter (2) to the sound pressure level sensor, a mechanical compensation link (9) is integrated in the high pressure adapter (2) and a sealing ring is inserted into the adapter opening (7).

Abstract

The object of the invention is to provide a sound pressure level calibrator, which is suitable for sound pressures to be measured in excess of 124 dB and which can be adapted to the installed sound pressure level sensor. This object is attained by a sound pressure level calibrator comprising a pistonphone (1) and a high-pressure adapter (2) connected to the output of the pistonphone. The high-pressure adapter (2) acts as a resonator (6). With an expanded adapter opening (7) the high-pressure adapter (2) is connected in soundproof manner with the sound pressure level sensor (3), which is inserted into a structure (10). The invention can be used for a sound pressure level calibrator to calibrate a sound pressure level sensor, which is integrated into a structure.

[Figure 1]

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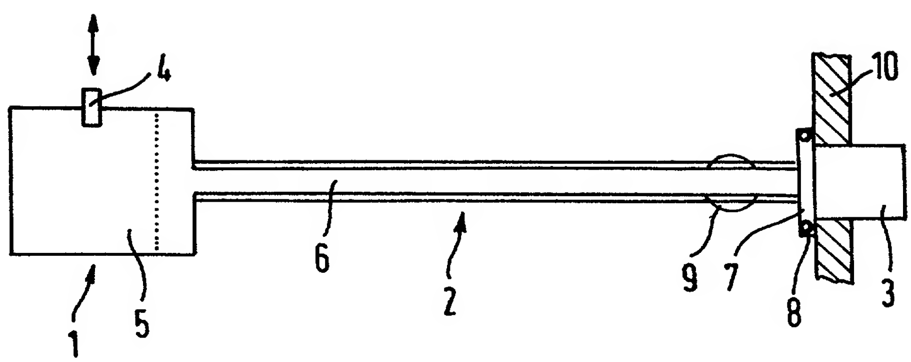

FIG.1

Attorney Docket No. 420/50943

DECLARATION AND POWER OF ATTORNEY

(For Use with Application Data Sheet)

As the below named inventor(s), I/we declare that:

This declaration is directed to:

___ The attached application, or
X International Application No. PCT/DE00/03478, filed on October 2, 2000,
___ as amended on ______________ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including material information which became available between the filing date of the prior application and the National or PCT International filing date of the continuation-in-part application, if applicable;

I/we hereby appoint the practitioners at **CROWELL & MORING L.L.P.**, whose Customer Number is:

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as my/our attorneys to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith; and

All statements made herein of my/our own knowledge are true; all statements made herein on information and belief are believed to be true, and further these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

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